

What is claimed is:

Claim 1: A method for setting a view point in a predetermined position with respect to a virtual three-dimensional image of an object to be examined formed by stack of a plurality of sectional images or formed from at least one volume image and setting projection plane for projecting said virtual three-dimensional image from said view point so that said virtual three-dimensional image from said view point is projected onto said projection plane to thereby form and display a projection image, said method comprising:

a reading step of reading out pixel values at intervals of a predetermined distance on a projection line with respect to said virtual three-dimensional image crossed by said projection line which goes from said view point toward said projection plane;

a recording step in which with respect to a plurality of pixel value memories provided respectively corresponding to a plurality of predetermined values different from each other and provided with recording regions for respectively recording pixels constituting an image, when the read-out pixel value fits to one of said predetermined values, the pixel data are recorded in the pixel recording region corresponding to the fitted predetermined value; and

a displaying step of reading out said pixel data stored in said pixel value memory and displaying said pixel data as a projection image on a display unit.

Claim 2: A method according to Claim 1, wherein said displaying step includes:

a weighting step of weighting pixel data read out from a plurality of ones of said pixel value memories by giving predetermined weighting coefficients to said pixel data by said pixel value memory;

a synthesizing step of synthesizing data on the basis of said weighted pixel data from said plurality of pixel value memories by an identical pixel; and

a displaying step of displaying said synthesized data.

Claim 3: A method according to Claim 2, wherein said weighting step is carried out so that a larger weighting coefficient is given to pixel data read out from a pixel value memory corresponding to a pixel value to be emphasized.

Claim 4: A method according to Claim 2, wherein said weighting coefficient given to pixel data from a pixel value memory corresponding to a pixel value to be not displayed on said display unit is set to zero.

Claim 5: A method according to Claim 2, wherein said weighting step includes:

a preparing step of preparing in advance a plurality of weighting coefficient curves in which weighting coefficients are set to be different from each other by said pixel value;

a displaying step of displaying a plurality of selection buttons corresponding to said plurality of weighting coefficient curves; and

an applying step of applying a weighting coefficient curve corresponding to one of said plurality of selection buttons to pixel data from said pixel value memory when said selection button is selected from said plurality of selection buttons.

Claim 6: A method according to Claim 5, further comprising a step of changing the characteristic of said weighting coefficient curve displayed on said display unit.

Claim 7: A method according to Claim 5, wherein both said projection image and said selected weighting coefficient curve are displayed on said display unit.

Claim 8: A method according to Claim 7, wherein when the characteristic of said weighting coefficient curve displayed is changed, a projection image which is weighted in accordance with the changed weighting coefficient curve is displayed on said display unit.

Claim 9: A method according to Claim 5, wherein a corresponding pixel value is displayed on a coordinate axis which expresses a pixel value on said weighting coefficient curve displayed on said display unit.

Claim 10: A method according to Claim 5, wherein the name of a portion of object to be examined corresponding to a pixel value is displayed in a

position corresponding to said pixel value on a coordinate axis which expresses a pixel value on said weighting coefficient curve displayed on said display unit.

Claim 11: A method according to Claim 1, further comprising a step of allocating a plurality of pixel value memories as a group among said pixel value memories to one memory region.

Claim 12: A method according to Claim 1, wherein said displaying step is carried out so that pixel data read out from one of said plurality of pixel value memories are displayed.

Claim 13: A method according to Claim 1, wherein said displaying step includes: a step of preparing in advance a plurality of weighting coefficient characteristics in which weighting coefficients different from each other by said pixel value are set; a step of forming a plurality of projection images corresponding to said plurality of weighting coefficient characteristics; and a step of displaying said plurality of thus formed projection images on said display unit.

Claim 14: A method according to Claim 1, wherein said recording step includes a process of adding said predetermined value to said pixel recording region whenever said fitting occurs.

Claim 15: A method according to Claim 14, wherein said displaying step is carried out so that said projection image is shaded in accordance with the size of pixel data recorded in said pixel value memory.

Claim 16: A method for setting a view point in a predetermined position with respect to a virtual three-dimensional image of an object to be examined formed by a stack of a plurality of sectional images or formed from at least one volume image and setting a projection plane for projecting said virtual three-dimensional image from said view point so that said virtual three-dimensional image is projected from said view point onto said projection plane to thereby form and display a projection image, said method comprising:

a reading step of reading out pixel values at intervals of a predetermined distance on a projection line with respect to said virtual three-dimensional image crossed by said projection line which goes from said view point toward said projection plane;

a recording step in which with respect to at least one pixel value memory provided corresponding to a predetermined value and provided with recording regions for respectively recording pixels constituting an image, only when the read-out pixel value first fits to said predetermined value, the pixel data are recorded in the pixel recording region corresponding to the fitted predetermined value; and

a displaying step of reading out said pixel data stored in said pixel value memory and displaying said pixel value data as a projection image on a display unit.

Claim 17: A method according to Claim 16, wherein said recording step includes: a step of calculating and recording the distance from said view point to the position where said pixel value read out by said reading step is present.

Claim 18: A method according to Claim 17, wherein said displaying step is carried out so that said projection image is displayed while shaded so that the brightness thereof is changed in accordance with the size of said distance.

Claim 19: A method according to Claim 1, wherein said view point is located at an infinite far point so that parallel projection is performed.

Claim 20: A method according to Claim 1, wherein said reading step is carried out so that, when said virtual three-dimensional image is formed by stack of a plurality of sectional images, pixel value reading-out is executed by a point at which said projection line passes through each of said sectional images.

Claim 21: A method according to Claim 1, wherein said reading step is carried out so that, when there is no pixel value in a pixel position to be read out, a pixel value which is obtained by executing interpolation on the pixel in said position is used as a read-out value.

Claim 22: A method according to Claim 1, wherein, only when a pixel value read in said reading step is fitted to a predetermined threshold condition, said recording step is processed on said pixel value fitted to said threshold condition.

Claim 23: A method according to Claim 1, wherein a predetermined range is given as said predetermined value in said recording step so that said fitting to execute said recording occurs when said read-out pixel value is contained in said range.

Claim 24: A method according to Claim 1, wherein said displaying step is carried out so that a plurality of images are displayed.

Claim 25: A method according to Claim 24, wherein said displaying step includes:

recording a first projection image formed under a first condition in a first predetermined address region designated in advance in a display memory;

recording a second projection image formed under a second condition in a second address region designated in advance in said display memory; and

displaying those image data recorded in said display memory on said display unit.

Claim 26: A method according to Claim 25, wherein said first and second conditions are different from each other in said view point or in said projection plane.

Claim 27: A method according to Claim 26, wherein virtual existing positions of said view point and said projection plane with respect to said first

projection image formed under said first condition are displayed on said second projection image.

Claim 28: A method according to Claim 25, wherein said first and second conditions are different from each other in weighting coefficient.

Claim 29: A method according to Claim 25, wherein said first and second conditions are different from each other in pixel value memory.

Claim 30: A method according to Claim 24, wherein said displaying step includes:

recording first image data read out from said pixel value memory in a first predetermined address region designated in advance in a display memory;

recording second image data different from said image data in a second address region designated in advance in said display memory; and

displaying those image data recorded in said display memory on said display unit.

Claim 31: A method according to Claim 30, wherein said second image data are image data formed by a maximum value projecting method.

Claim 32: A method according to Claim 30, wherein said second image data are formed from predetermined one of said plurality of sectional images.

Claim 33: A method according to Claim 24, wherein said displaying step includes:

receiving information pertinent to the movement of a medical tool which moves in said object to be examined;

recording said projection image in a display memory; and

recording image data of said medical tool based on said information pertinent to the movement thereof in said display memory in order to synthesize said image data with said projection image.

Claim 34: A method according to Claim 33, wherein said projection images to be subjected to said synthesizing are formed from image data read out from a pixel value memory with respect to a pixel value pertinent to a blood vessel in which said medical tool is to be inserted.

Claim 35: A method according to Claim 1, wherein said displaying step includes:

recording, in a first display memory, a first projection image formed at a first view point;

recording, in a second display memory, a second projection image formed at a second view point moved by a distance corresponding to parallax from said first view point;

displaying said first and second projection images alternately on said display unit; and

making said projection images stereoscopic so that said projection images displayed on said display unit are observed alternately by the left and right eyes of an observer in synchronism with said alternate displaying.

Claim 36: A method according to Claim 1, wherein pixel data in a pixel value memory corresponding to a pixel value pertinent to a required observed portion are displayed intermittently on said display unit so that said portion of object to be examined is displayed so as to be blinked.

Claim 37: A method according to Claim 1, wherein said displaying step further includes:

preparing a color map in which a plurality of colors containing white and black are classified in accordance pixel value ranges to be allocated to classes of said color map;

standardizing each pixel value range to a corresponding class of said color map; and

synthesizing a projection image from pixel data thus standardized.

Claim 38: A method according to Claim 2, further comprising:
a condition change step of successively changing a condition containing at least one of said view point, said projection plane, and said weighting coefficient given to pixel data read out from said pixel value memory;

an image processing step of performing image processing by executing a process from said reading step to said executing step whenever said condition is changed; and

a projection image group forming step of forming a group of projection images by recording pixel data, which are obtained as a result of said image processing in said pixel value memory, as projection images in a plurality of recording regions successively;

wherein said displaying step is carried out so that projection images stored in said plurality of storage regions are read out successively so as to be displayed as an animated image on said display unit.

Claim 39: A method according to Claim 38, wherein said condition changing step is carried out so that said view point is rotated around a required center axis of said observed object and said projection images are displayed as a rotating image of said observed object in said displaying step.

Claim 40: A method according to Claim 38, wherein said condition changing step includes:

a first condition changing step of changing said view point successively;

a second condition changing step of changing said weighting coefficient successively;

a first condition changing executing step of executing both said image processing step and said projection image group forming step in accordance with said first condition changing step; and

a second condition changing executing step of executing said first condition changing executing step whenever said second condition is changed in said second condition changing step;

whereby a plurality of groups of projection images are formed.

Claim 41: A recording medium which can be read by a computer and which has a program for executing:

a function for setting both a view point and a projection plane;

a function for reading out pixel values at intervals of a predetermined distance on a projection line with respect to a virtual three-dimensional image crossed by said projection line which goes from said view point toward said projection plane;

a function in which, with respect to a plurality of pixel value memories provided respectively corresponding to a plurality of predetermined values different from each other and provided with recording regions for respectively recording pixels constituting an image, when the read-out pixel value fits to one of said predetermined values, the pixel data are recorded in the pixel recording region corresponding to the fitted predetermined value; and

a function for reading pixel data recorded in said pixel value memory to form a projection image;

said program being recorded in said recording medium so that a virtual three-dimensional image of an object to be examined formed by stack of a plurality of sectional images or formed of at least one volume image is projected from said view point onto said projection plane to thereby form a projection image.

Claim 42: An apparatus for setting a view point in a predetermined position with respect to a virtual three-dimensional image of an object to be examined formed by stack of a plurality of sectional images or formed from at least one volume image and setting a projection plane for projecting said virtual three-dimensional image from said view point is set so that said virtual three-dimensional image is projected onto said projection plane from said view point to thereby form and display a projection image, comprising:

reading means for reading out pixel values at intervals of a predetermined distance on a projection line with respect to said virtual three-dimensional image crossed by said projection line which goes from said view point toward said projection plane;

a plurality of pixel value memories which are provided so as to respectively correspond to a plurality of predetermined values different from each other and which are provided with recording regions for recording pixels constituting an image;

recording means in which said recording means records pixel data, when the pixel value read out by said reading means is fitted to one of said predetermined values, in a pixel recording region corresponding to said fitted predetermined value;

pixel data reading means for reading out pixel data recorded in said pixel value memory; and

a display unit for displaying, as a projection image, pixel data read out by said pixel data reading means.

Claim 43: An apparatus according to Claim 42, wherein said pixel value memory is a pixel value counting memory in which said predetermined value is added whenever said fitting occurs.

Claim 44: An apparatus according to Claim 42, wherein said pixel value memory is a pixel value marking bit memory in which said recording is executed when said fitting occurs first but said recording is not executed when said fitting occurs after that.

Claim 45: An apparatus according to Claim 48, further comprising a distance memory for recording the distance from said view point to the existing position of said pixel value when said recording is executed.

Claim 46: An apparatus according to Claim 45, wherein said display unit is designed so that said projection image is displayed on said display unit while the brightness thereof is changed in accordance with the distance recorded in said distance memory.

Claim 47: An apparatus according to Claim 42, wherein said pixel data reading means includes a display memory for recording said read-out pixel data.

Claim 48: An apparatus according to Claim 47, wherein: a plurality of said pixel value memories are provided; and said pixel data reading means

includes addition means for adding pixel data recorded in corresponding pixel recording regions in selected ones of said plurality of pixel value memories; pixel data memory for recording pixel data added by said addition means; and means for recording the added pixel data in said pixel data memory, into a corresponding pixel recording region of said display memory.

Claim 49: An apparatus according to Claim 48, wherein said addition means further applies required weighting to each of said pixel value memories, so that each of said pixel data read out from said pixel value memories is multiplied by a weighting coefficient corresponding to the degree of said weighting.

Claim 50: A method according to Claim 1, further comprising an executing step for making said projection line scan by pixel on said projection plan and for executing said reading step and said recording step every time a scanned pixel comes during the scanning.

Claim 51: A recording medium according to Claim 41, further comprising an executing function for making said projection line scan by pixel on said projection plan and for executing said reading function and said recording function every time a scanned pixel comes during the scanning.

Claim 52: An apparatus according to Claim 42, further comprising executing means for making said projection line scan all pixels on said projection

plane and for operating said reading means and said recording means each time a pixel is scanned.

Claim 53: A recording medium which can be read by a computer and which has a program for executing:

a function for setting both a view point and a projection plane;

a function for reading out pixel values at intervals of a predetermined distance on a projection line with respect to a virtual three-dimensional image crossed by said projection line which goes from said view point toward said projection plane;

a function in which, with respect to at least one pixel value memory provided corresponding to a predetermined value and provided with recording regions for respectively recording pixels constituting an image, only when the read-out pixel value first fits to said predetermined value, the pixel data are recorded in the pixel recording region corresponding to the fitted predetermined value; and

a function for reading pixel data recorded in said pixel value memory to form a projection image;

said program being recorded in said recording medium so that a virtual three-dimensional image of an object to be examined formed by stack of a plurality of sectional images or formed of at least one volume image is projected from said view point onto said projection plane to thereby form a projection image.

Claim 54: An apparatus for setting a view point in a predetermined position with respect to a virtual three-dimensional image of an object to be examined formed by stack of a plurality of sectional images or formed from at least

one volume image and setting a projection plane for projecting said virtual three-dimensional image from said view point so that said virtual three-dimensional image is projected onto said projection plane from said view point to thereby form and display a projection image, comprising:

reading means for reading out pixel values at intervals of a predetermined distance on a projection line with respect to said virtual three-dimensional image crossed by said projection line which goes from said view point toward said projection plane;

at least one pixel value memory provided so as to correspond to a predetermined value and provided with recording regions for recording pixels constituting an image;

recording means in which said recording means records pixel data, only when the pixel value read out by said reading means is first fitted to said predetermined value, in a pixel recording region corresponding to said fitted predetermined value;

pixel data reading means for reading out pixel data recorded in said pixel value memory; and

a display unit for displaying, as a projection image, pixel data read out by said pixel data reading means.

Claim 55: A method according to Claim 28, wherein said first and second coefficients being different from each other in weighting coefficient causes said first projection image to be displayed more emphatically than said second projection image in said displaying step.

Claim 56: A method according to Claim 1, wherein said virtual three-dimensional image is formed by one of (1) a plurality of CT images from an X-ray CT system, (2) a plurality of MRI images from an MRI system, (3) a plurality of sectional images from an ultrasonic tomograph system, and (4) a solid image in a solid region having a required thickness.

Claim 57: A method for setting a view point in a predetermined position with respect to an image of an object to be examined formed by stack of a plurality of sectional images or formed from at least one volume image and setting a projection plane for projecting said image in a position in opposition to said view point so that a projection image of said image is projected, wherein:

said projection image includes at least a first projection image of a first organ or region and a second projection image of a second organ or region, and

said first projection image is displayed more emphatically than said second projection image.

Claim 58: A method according to Claim 57, wherein said emphatic displaying is performed by giving different weighting coefficients to said first projection image and said second projection image respectively.

Claim 59: A method according to Claim 57, wherein said emphatic displaying is performed by making luminance different between said first projection image and said second projection image.

Claim 60: A method according to Claim 57, wherein said emphatic displaying is performed by making density different between said first projection image and said second projection image.

Claim 61: A method according to Claim 57, wherein said emphatic displaying is performed by making gradation different between said first projection image and said second projection image.

Claim 62: A method according to Claim 57, further comprising a step of displaying information indicating degree of the emphasis adjacently to the emphasized projection image.

Claim 63: A method according to Claim 57, further comprising a step of displaying a not-emphasized projection image and an emphasized projection image or a plurality of differently emphasized projection images adjacently to each other.

Claim 64: A recording medium which can be read by a computer and which has a program for realizing, with respect to a projection image including at least a first projection image of a first organ or region and a second projection image of a second organ or region, a function for displaying said first projection image more emphatically than said second projection image.

Claim 65: A method according to Claim 64, wherein said emphatic displaying is performed by giving different weighting coefficients to said first projection image and said second projection image respectively.

Claim 66: A method according to Claim 64, wherein said emphatic displaying is performed by making luminance different between said first projection image and said second projection image.

Claim 67: A method according to Claim 64, wherein said emphatic displaying is performed by making density different between said first projection image and said second projection image.

Claim 68: A method according to Claim 64, wherein said emphatic displaying is performed by making gradation different between said first projection image and said second projection image.

Claim 69: A method according to Claim 64, further comprising a step of displaying information indicating degree of the emphasis adjacently to the emphasized projection image.

Claim 70: A method according to Claim 64, further comprising a step of displaying a not-emphasized projection image and an emphasized projection image or a plurality of differently emphasized projection images adjacently to each other.

Claim 71: An apparatus comprising:

first recording means for recording an image of an object to be examined formed by stack of a plurality of sectional images or formed from at least one volume image;

image processing means for setting a view point in a necessary position and setting a projection plane for projecting said image in a position in opposition to said view point so that a projection image of said image is formed;

second recording means for recording said projection image; and

a displaying means for displaying said projection image, wherein:

said projection image includes at least a first projection image of a first organ or region and a second projection image of a second organ or region, said first and second projection images being recorded in memories different from each other, and

said image processing means forms emphasized projection images in which said first projection image is more emphasized than said second projection image, and

said displaying means displays said emphasized projection images.

Claim 72: An apparatus according to Claim 71, wherein said image processing means gives different weighting coefficients to said first projection image and said second projection image respectively.

Claim 73: An apparatus according to Claim 71, wherein said image processing means forms emphasized projection images of said first and second

projection images which are emphasized in luminance, and said displaying means displays said luminance-emphasized projection images.

Claim 74: An apparatus according to Claim 71, wherein said image processing means forms emphasized projection images of said first and second projection images which are emphasized in density, and said displaying means displays said density-emphasized projection images.

Claim 75: An apparatus according to Claim 71, wherein said image processing means forms emphasized projection images of said first and second projection images which are emphasized in gradation, and said displaying means displays said gradation-emphasized projection images.

Claim 76: An apparatus according to Claim 71, wherein said displaying means displays information indicating degree of the emphasis adjacently to the emphasized projection image.

Claim 77: An apparatus according to Claim 71, wherein said displaying means displays a not-emphasized projection image and an emphasized projection image or a plurality of differently emphasized projection images adjacently to each other.

Claim 78: A projection image forming and displaying method, comprising:

displaying a projection image and a distribution curve of weighting for CT values in said projection image;

setting the weighting for a CT value on said distribution curve displayed to a required value; and

displaying by highlighting said CT value weighted.

Claim 79: A projection image forming and displaying method, comprising:

displaying a projection image;

setting a required sectional image of said projection image displayed; and

displaying by highlighting said required sectional image.